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(54) **DYNAMICALLY CONFIGURING A HONEYPOT**

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H04L 29/06	(2006.01)
G06N 20/00	(2019.01)
G06F 16/951	(2019.01)

(52) **U.S. Cl.**

CPC ***H04L 63/1491*** (2013.01); ***G06F 16/951*** (2019.01); ***G06N 20/00*** (2019.01); ***H04L 63/1408*** (2013.01)

(58) **Field of Classification Search**

CPC H04L 63/1491
USPC 726/22
See application file for complete search history.

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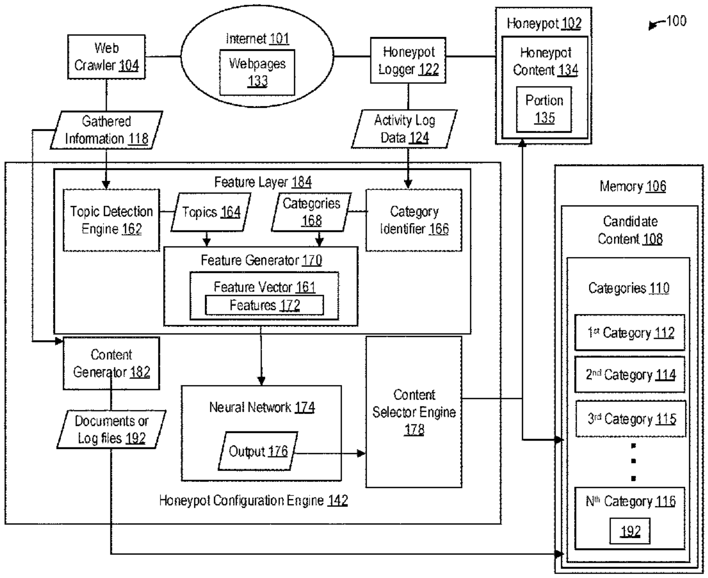
(57) **ABSTRACT**

A computer-implemented method includes crawling, by a web crawler, one or more webpages to gather information, resulting in gathered information. The computer-implemented method includes obtaining, by a honeypot logger, activity log data of one or more hackers that access a portion of honeypot content deployed by a honeypot. The computer-implemented method includes dynamically configuring, by a machine capable of learning, the honeypot using the activity log data and the gathered information.

17 Claims, 6 Drawing Sheets



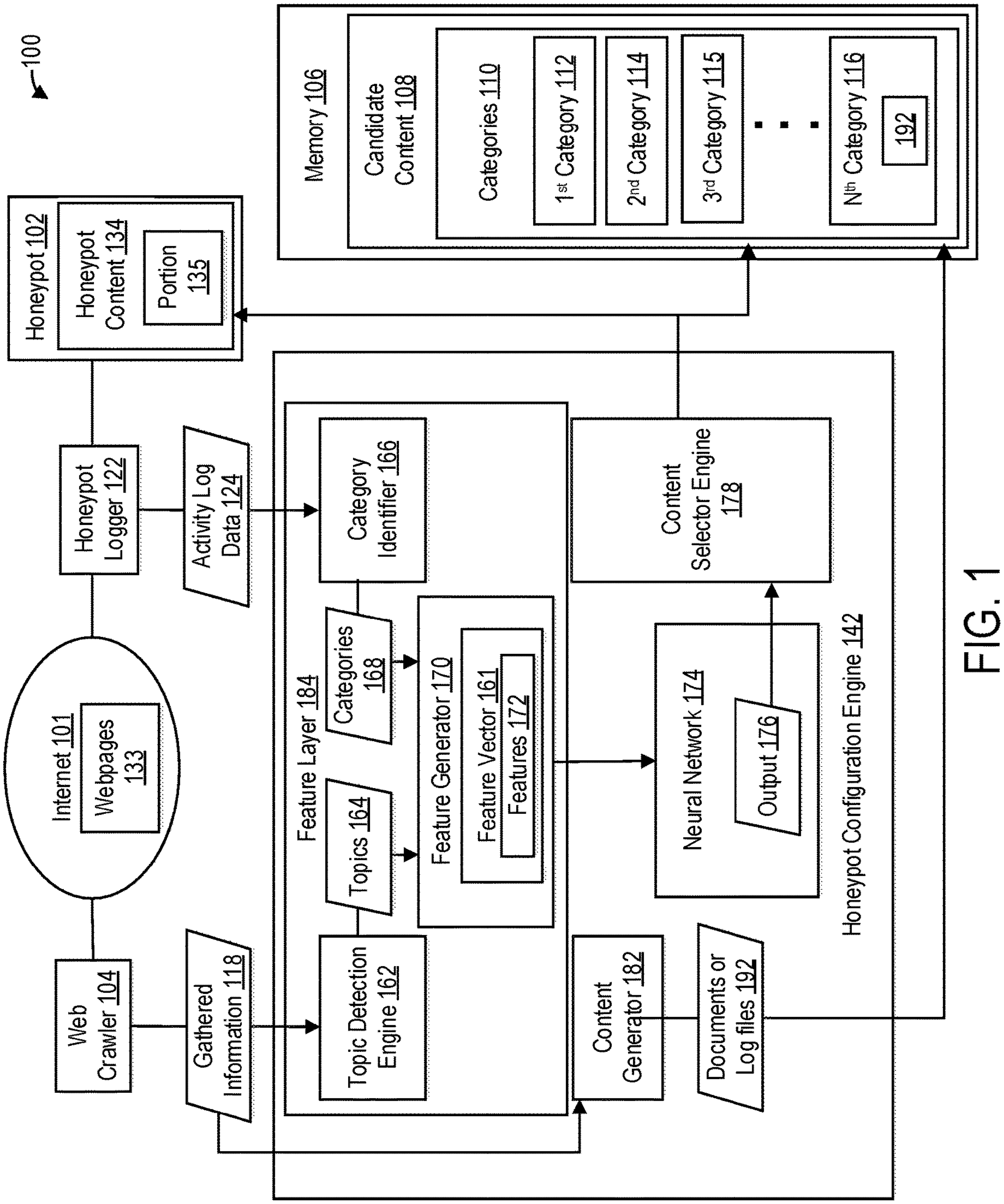

100
Honeypot 102
Honeypot Content 134
Portion 135
Memory 106
Candidate Content 108
Categories 110
1st Category 112
2nd Category 114
3rd Category 115
Nth Category 116
192
Internet 101
Webpages 133
Web Crawler 104
Honeypot Logger 122
Activity Log Data 124
Gathered Information 118
Feature Layer 184
Topic Detection Engine 162
Topics 164
Categories 168
Category Identifier 166
Feature Generator 170
Feature Vector 161
Features 172
Content Selector Engine 178
Neural Network 174
Output 176
Content Generator 182
Documents or Log files 192
Honeypot Configuration Engine 142

FIG. 1

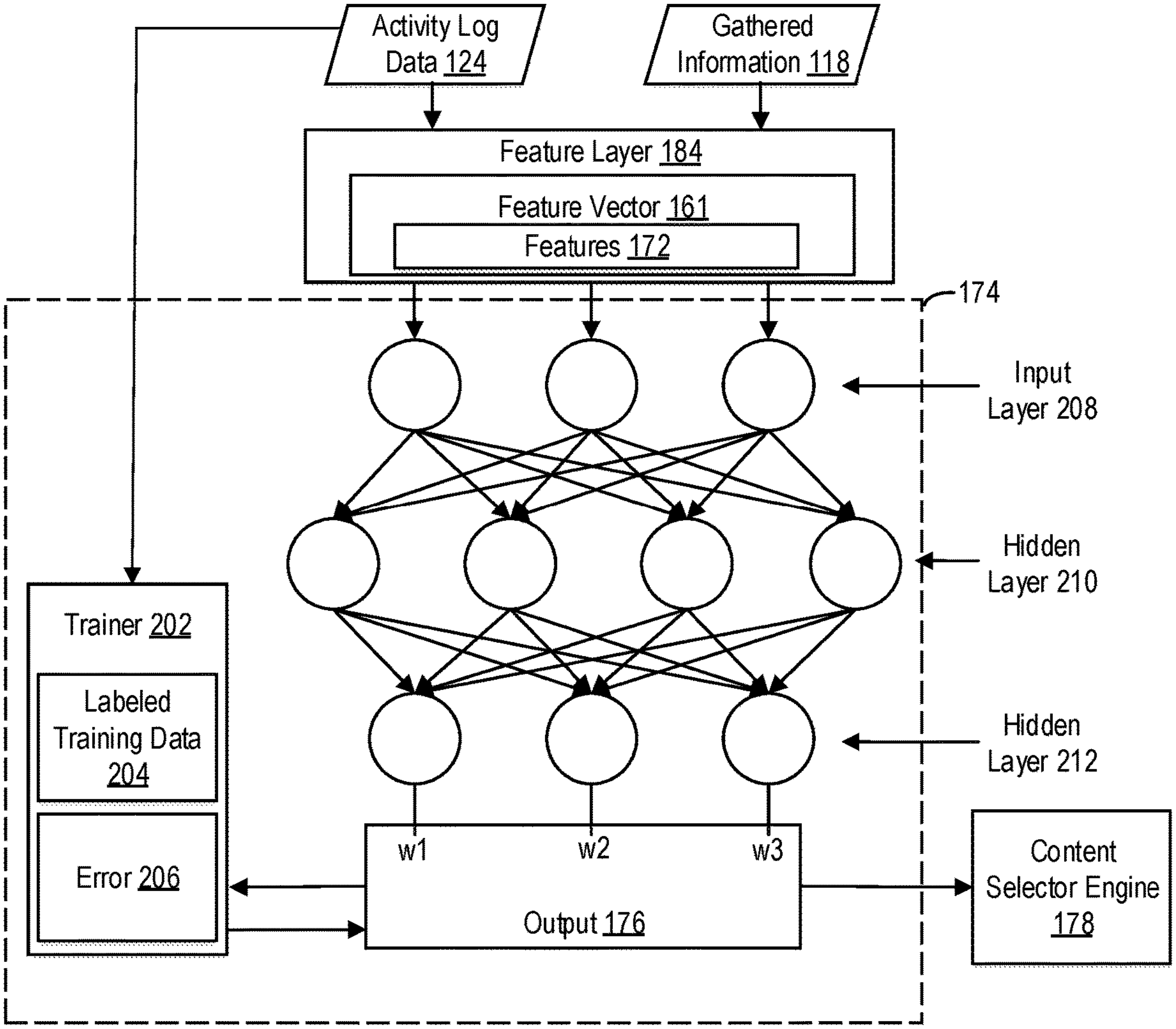

Activity Log Data 124
Gathered Information 118
Feature Layer 184
Feature Vector 161
Features 172
174
Input Layer 208
Hidden Layer 210
Hidden Layer 212
Trainer 202
Labeled Training Data 204
Error 206
w1
w2
w3
Output 176
Content Selector Engine 178

FIG. 2

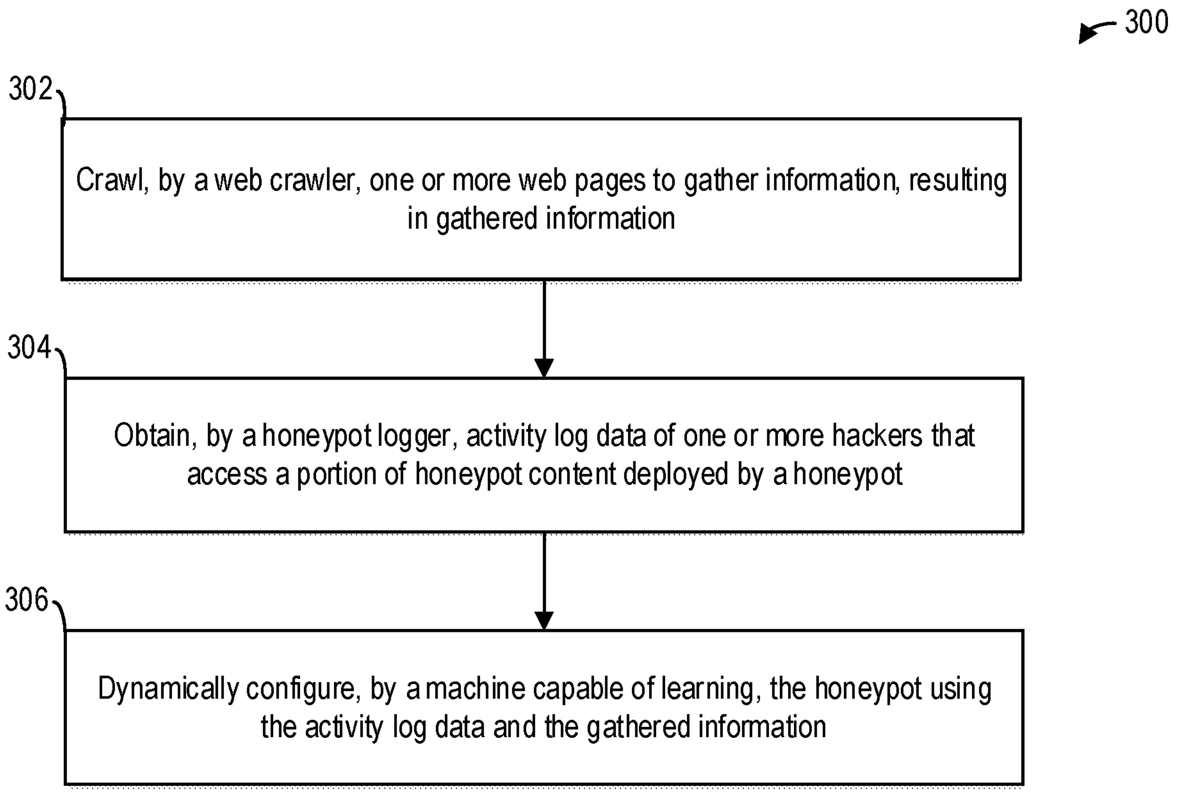

300
302
Crawl, by a web crawler, one or more web pages to gather information, resulting in gathered information
304
Obtain, by a honeypot logger, activity log data of one or more hackers that access a portion of honeypot content deployed by a honeypot
306
Dynamically configure, by a machine capable of learning, the honeypot using the activity log data and the gathered information

FIG. 3

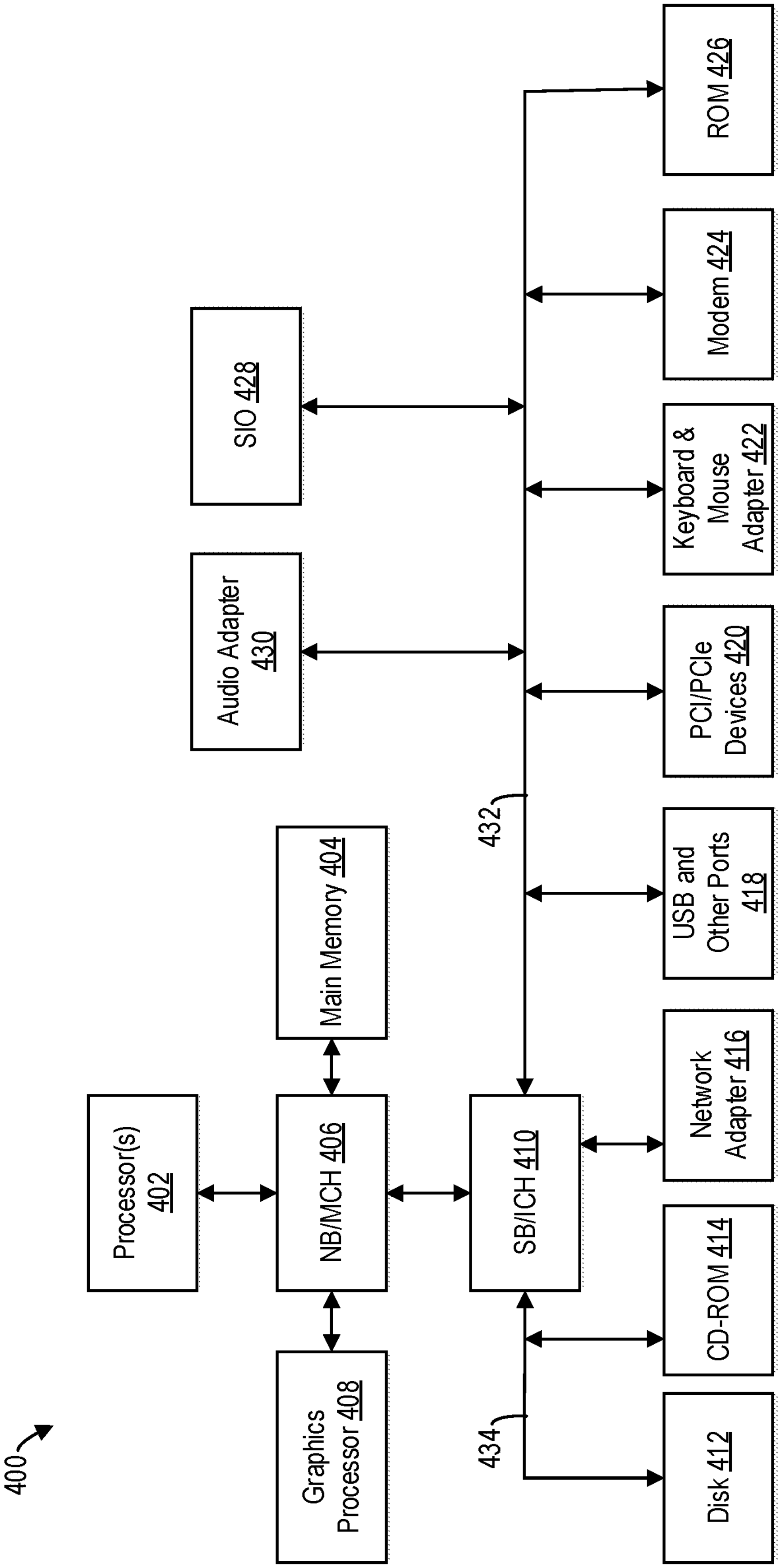

400
Processor(s) 402
Graphics Processor 408
NB/MCH 406
Main Memory 404
SB/ICH 410
Disk 412
CD-ROM 414
Network Adapter 416
USB and Other Ports 418
PCI/PCIe Devices 420
Keyboard & Mouse Adapter 422
Modem 424
ROM 426
SIO 428
Audio Adapter 430
432
434

FIG. 4

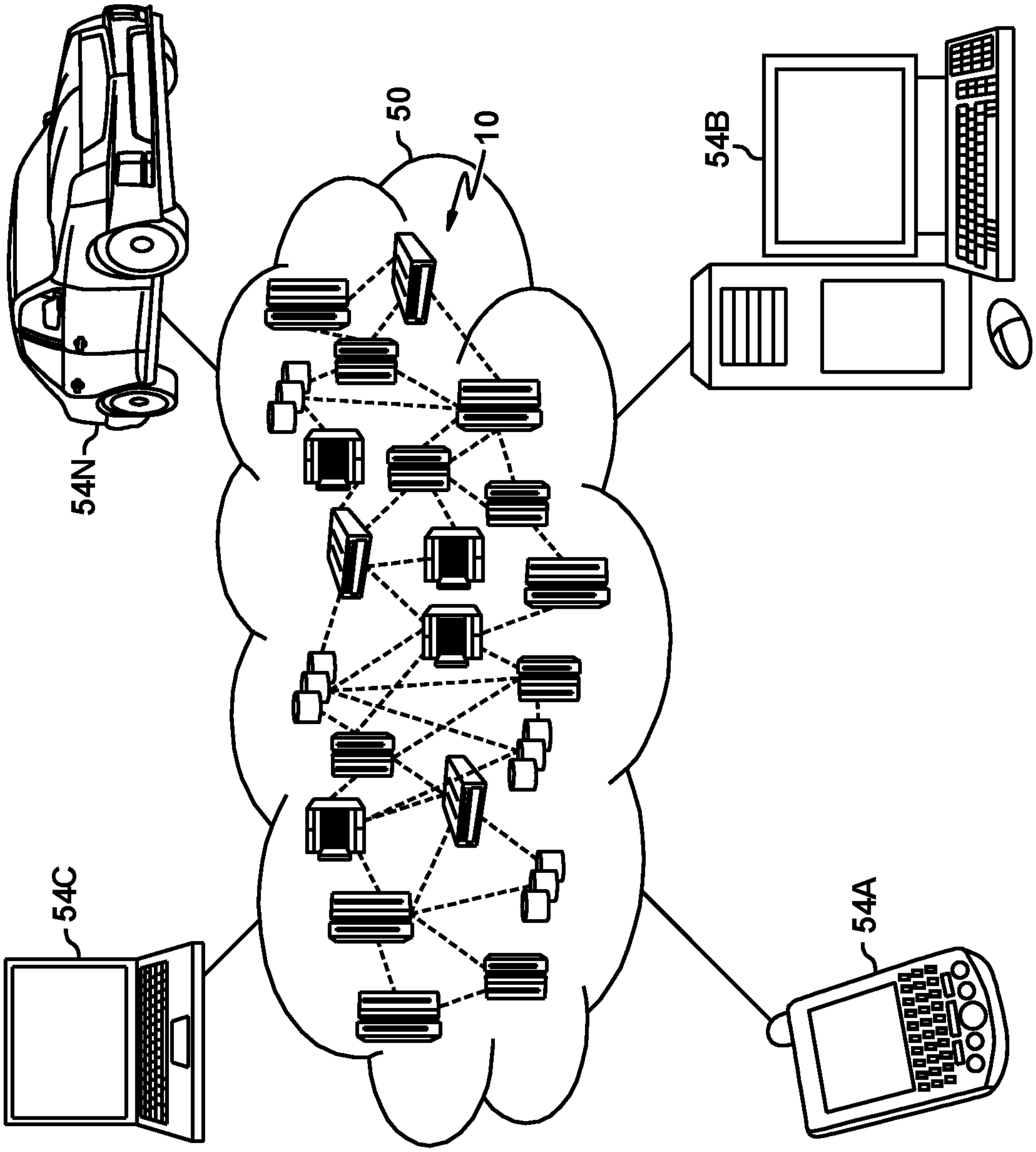


FIG. 5

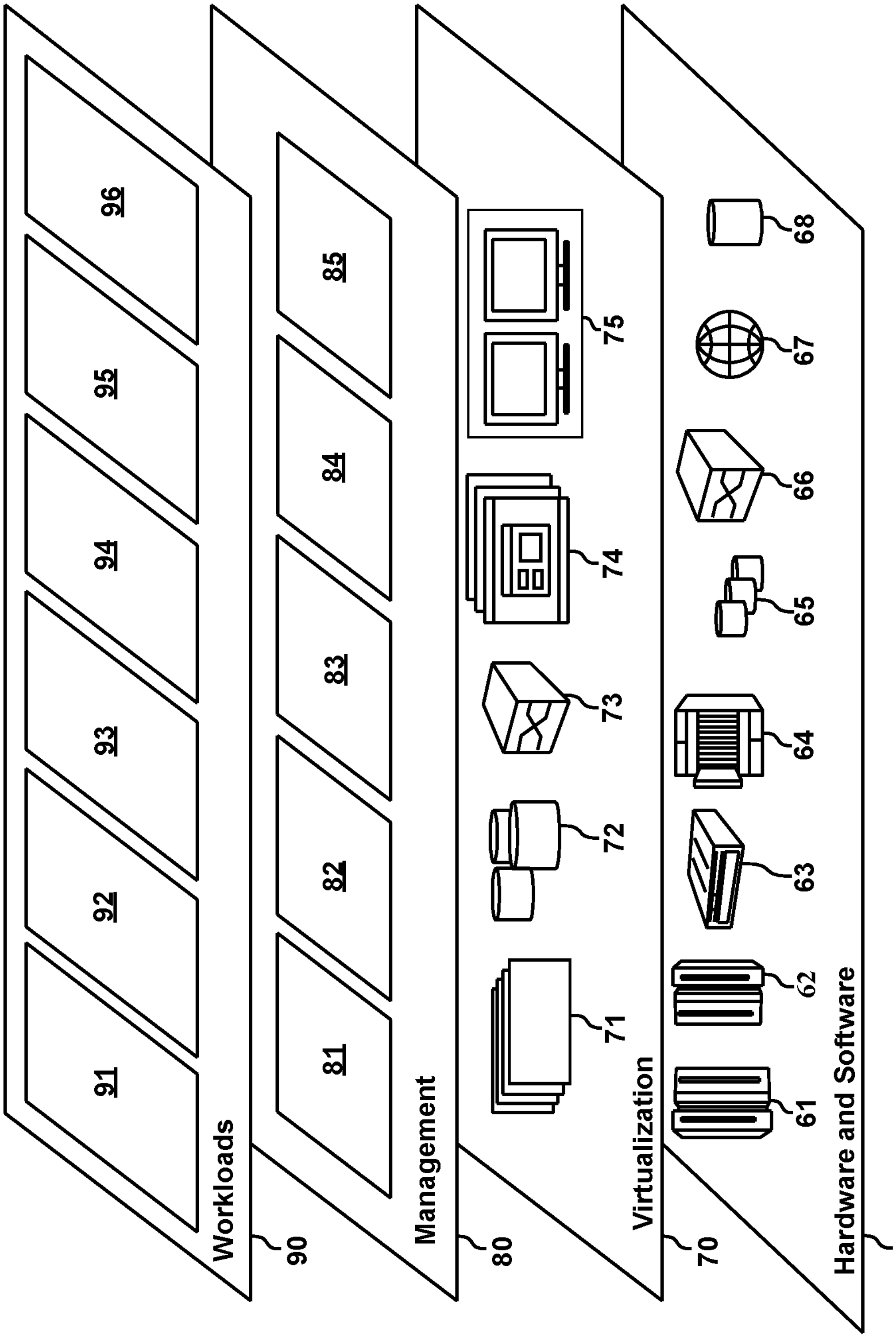

Workloads
90
91
92
93
94
95
96
Management
80
81
82
83
84
85
Virtualization
70
71
72
73
74
75
Hardware and Software
60
61
62
63
64
65
66
67
68

FIG. 6

DYNAMICALLY CONFIGURING A HONEYPOT

BACKGROUND

The present disclosure relates to honeypots. Honeypots are used to draw the attention of hackers away from potentially vulnerable targets, to waste hackers' time attacking a false target, and to gather information about hackers' tools and methods of attack. Current techniques to attract and hold the attention of hackers without the hackers detecting the honeypot require manual reconfiguration and customization of the honeypot and are not effective. There is a need to configure honeypots to attract and hold the attention of hackers without the hackers detecting the honeypot system.

SUMMARY

According to an embodiment of the present disclosure, a computer-implemented method includes crawling, by a web crawler, one or more webpages to gather information, resulting in gathered information. The computer-implemented method further includes obtaining, by a honeypot logger, activity log data of one or more hackers that access a portion of honeypot content deployed by a honeypot. The computer-implemented method further includes dynamically configuring, by a machine capable of learning, the honeypot using the activity log data and the gathered information. Dynamically configuring the honeypot based on detected activity from hackers and based on the gathered information results in the honeypot appearing more interesting to hackers.

In some optional implementations, dynamically configuring the honeypot using the activity log data and the gathered information includes parsing the activity log data to determine first categories associated with the portion of the honeypot content that is accessed by the one or more hackers, performing topic detection on the gathered information to identify one or more topics, and selecting the honeypot content based on the first categories and the one or more topics. In some optional implementations, the first categories associated with the portion of the honeypot content that is accessed by hackers are indicative of which categories of honeypot content the hackers are interested in. In some optional implementations, the topics associated with the gathered information are indicative of current events that are likely to be of interest to the hackers. Selecting the honeypot content based on information indicative of which categories of honeypot content the hackers are interested in and based on gathered information indicative of current events that are likely to be of interest to the hackers increases the chances that the honeypot will appear more attractive to the hackers.

In some optional implementations, the computer implemented method includes generating one or more documents or log files using the gathered information, and adding the one or more documents or log files to the candidate content. Because the computer-implemented method generates content based on the gathered information, the honeypot content may appear more up to date and therefore less likely to trigger a hacker to detect that the honeypot is a honeypot.

Embodiments of the disclosure also include a system and a computer program product that includes a computer readable storage medium having program instructions embodied therewith.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows an illustrative block diagram of a system configured to dynamically configure a honeypot using activity log data from a honeypot logger and using information gathered by a web crawler;

FIG. **2** shows an illustrative diagram of an example of neural network of the system of FIG. **1**;

FIG. **3** shows an illustrative flowchart illustrating aspects of operations that may be performed to dynamically configure a honeypot;

FIG. **4** shows an illustrative block diagram of an example system that can be applied to implement embodiments of the present disclosure;

FIG. **5** depicts a cloud computing environment according to various embodiments; and

FIG. **6** depicts abstraction model layers according to various embodiments.

DETAILED DESCRIPTION

With reference now to FIG. **1**, a block diagram of a system **100** configured to dynamically configure a honeypot **102** is illustrated. The system **100** may be used by a company or organization to draw the attention of hackers away from potentially vulnerable targets, to waste hackers' time attacking a false target, and to gather information about hackers' tools and methods of attack. The system **100** includes a honeypot configuration engine **142** coupled to a memory **106**. The memory **106** stores candidate content **108**. The honeypot **102** deploys honeypot content **134** that is selected from the candidate content **108** as described in more detail below. The memory **106** corresponds to, or includes, a tangible device that can retain and store the candidate content **108**. The memory **106** may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the memory **106** includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM) or Flash memory, a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing.

The candidate content **108** includes different categories **110** of content. For example, the candidate content **108** may include N categories of content, where N is greater than one. To illustrate, the different categories **110** of content may include a first category **112** of content, a second category **114** of content, a third category **115** of content, and an Nth category **116** (e.g., a fourth or greater than fourth) of content. In some examples, the first category **112** of content corresponds to financial data content, the second category **114** of content corresponds to strategy content, the third category **115** of content corresponds to health care data content, and the Nth category **116** of content corresponds to intellectual property data content.

The system **100** additionally includes a web crawler **104** configured to crawl one or more webpages **133** to gather information, resulting in gathered information **118**. The gathered information **118** may include current news articles and social media activity regarding a company or organization that uses the system **100**. For example, the web crawler **104** may be configured to be connected to the Internet **101** via a wired or wireless connection, such as a wireless local area network ("WLAN"), and the web crawler **104** may configured with a web crawling capability, such as Blekko™ or AlchemyData News, to crawl the web to gather information (e.g., articles, documents, blog material, social media information regarding the company) from websites.

The system **100** includes a honeypot logger **122** (e.g., a honeywall) to obtain activity log data **124** of one or more hackers that access a portion **135** of the honeypot content **134** deployed by the honeypot **102**. The honeypot logger **122** is configured to be connected to the Internet **101** via a wired or wireless connection, such as a WLAN. The activity log data **124** may indicate which documents, data, folders, or targets the one or more hackers access, a time of the access, a duration of the access, and/or a number of accesses. The honeypot logger **122** may be configured to obtain the activity log data **124** using keystroke logging techniques. However, the honeypot logger **122** may employ additional or alternative techniques to keystroke logging to obtain the activity log data **124**.

The honeypot configuration engine **142** is coupled to the web crawler **104** and the honeypot logger **122** and is configured with machine learning capability (e.g., a neural network **174**) to dynamically configure the honeypot **102** using the activity log data **124** and the gathered information **118**. The honeypot configuration engine **142** is configured to dynamically configure the honeypot **102** by selecting which content of the candidate content **108** to deploy via the honeypot **102**.

The honeypot configuration engine **142** includes a feature layer **184** that includes a topic detection engine **162**, a category identifier **166**, and a feature generator **170**. The topic detection engine **162** is configured with topic detection or modeling capability to perform topic detection on the gathered information **118** to identify one or more topics **164** related to a company or organization that uses the system **100**. In some examples, the one or more topics **164** are indicative of current events regarding the company or organization that uses the system **100** and that are likely to be of interest to hackers. In some examples, the topic detection engine **162** is configured with modeling capability such as latent Dirichlet allocation (LDA) capability, latent semantic analysis (LSA), and/or term frequency-inverse document frequency (TF-IDF) capability to perform the topic detection. The category identifier **166** is configured to parse the activity log data **124** to determine first categories **168** associated with the portion **135** of the honeypot content **134** that is accessed by the one or more hackers. In some examples, the first categories **168** are indicative of which categories of the honeypot content **134** the one or more hackers are interested in.

The feature generator **170** is configured to extract features **172** using the one or more topics **164** and using the first categories **168**, and is configured to generate a feature vector **161** based on the features **172**. The feature generator **170** is configured to provide the feature vector **161** for input to the neural network **174**. The neural network **174** is configured to process the feature vector **161** to generate output **176**. In some examples, the neural network **174** is or includes a multilayer perceptron. Alternatively or additionally, the neural network **174** is or includes a Restricted Boltzmann machine. Alternatively or additionally, the neural network **174** is or includes a Deep Belief Network. In some examples, the neural network **174** is trained using labeled training data based on the activity log data **124** as described in more detail below with reference to FIG. **2**. The neural network **174** is configured to generate the output **176** by applying network weights or biases, along with one or more activation functions, to data passing through the neural network **174**. In some examples, the output **176** may correspond to weights or biases. For example, the output **176** may include weights, and each of the weights may be associated with a respective category of the different categories **110** of the candidate content **108**. In some examples, each of the weights of the output **176** is indicative of how much of a particular category of the different categories **110** to include in the honeypot content **134**. The neural network **174** may be trained (e.g., by configuring the network weights and biases of the neural network **174**) using labeled training data generated based on the activity log data **124** as described in more detail below with reference to FIG. **2**.

The honeypot configuration engine **142** includes a content selector engine **178** configured to select the honeypot content **134** based on the output **176** generated by the neural network **174** using features extracted from the first categories **168** and the one or more topics **164**. To illustrate, in an example, the output **176** includes weights, and each of the output weights is associated with a respective category of the different categories **110** of the candidate content **108**. In this example, each of the weights of the output **176** is indicative of how much of a particular category of the different categories **110** to include in the honeypot content **134**. In this example, the content selector engine **178** is configured to select the honeypot content **134** from the candidate content **108** based on the weights in the output **176**. For example, the weights in the output **176** may include a first weight indicating how much of the first category **112** of content to include in the honeypot content **134**, a second weight indicating how much of the second category **114** of content to include in the honeypot content **134**, a third weight indicating how much of the third category **115** of content to include in the honeypot content **134**, and an Nth weight indicating how much of the Nth category **116** of content to include in the honeypot content **134**.

Thus, the honeypot configuration engine **142** is configured to select content for the honeypot **102** based on weights or biases output from a neural network that is fed feature input based on the gathered information **118** and the activity log data **124**. Because the honeypot content **134** is selected based on detected activity from hackers and information of interest (e.g., gathered information **118**), the honeypot **102** may appear more interesting to hackers than honeypots that do not select content in consideration of hacker activity on the honeypot **102** and based on information of interest.

In response to selecting the honeypot content **134**, the honeypot configuration engine **142** is configured to cause the honeypot **102** to deploy the honeypot content **134**. For example, the honeypot configuration engine **142** may send the honeypot **102** one or more instructions that causes the honeypot **102** to make the honeypot content **134** selected by the honeypot configuration engine **142** available to potential hackers.

In some examples, the honeypot configuration engine **142** is configured to additionally or alternatively dynamically configure the honeypot **102** by generating content (e.g., documents of log files **192**) based on the gathered information **118**. For example, the honeypot configuration engine **142** may include a content generator **182** configured to generate fake notes appearing to be about the gathered information **118** (e.g., new articles) or appearing to tie the gathered information **118** (e.g., news articles) to fake project names assigned to the honeypot content **134**. In some examples, the content generator **182** stores a set of template notes that include blank portions for insertion of topics detected from the gathered information **118**. In some examples, the template notes are stored in the form of email, text messaging log files, or email ostensibly pasted into documents. The honeypot configuration engine **142** is configured to cause the documents or log files **192** to be added to the candidate content **108** stored in the memory **106**. Because the honeypot configuration engine **142** generates content based on the gathered information **118**, the honeypot content **134** may appear more up to date and therefore less likely to trigger a hacker to detect that the honeypot **102** is a honeypot.

The honeypot **102** configured using the honeypot configuration engine **142** may be deployed by an entity such as a company or organization that employs production systems. When deployed, the configured honeypot **102** makes available or accessible the honeypot content **134** to one or more hackers, and the honeypot logger **122** may be configured to gather information that the entity deploying the honeypot **102** can use to secure the entity's production systems.

FIG. **2** illustrates an example of the neural network **174** of FIG. **1**. The neural network **174** of FIG. **2** may correspond to a multilayer perceptron. The neural network **174** of FIG. **2** includes an input layer **208** (e.g., a visible layer) configured to receive the feature vector **161** from the feature layer **184**. The neural network **174** of FIG. **2** also includes a hidden layer **210** and a hidden layer **212**. Although the neural network **174** of FIG. **2** is illustrated as including two hidden layers, in other examples, the neural network **174** includes more than or less than two hidden layers.

Each node in the hidden layers **210** and **212** is a neuron that maps inputs to the outputs by performing linear combination of the inputs with the node's network weight(s) and bias and applying a nonlinear activation function. The hidden layer **212** may correspond to an output layer, and a number of nodes in the output layer may correspond to a number of classes or categories of content. For example, the different categories **110** of the candidate content **108** of FIG. **1** may include N categories, and the number of nodes in the output layer may therefore also include N categories. The output **176** includes a plurality of weights w**1**, w**2**, and w**3**. Although the output **176** is illustrated as including three output weights, in other examples, the output **176** includes more than or less than three output weights (e.g., the output **176** may include a number of output weights corresponding to a number of the different categories **110**). The weights w**1**, w**2**, and w**3** may be associated with the different categories **110** of the candidate content **108** of FIG. **1** and may be provided to the content selector engine **178**. For example, the different categories **110** of content may include N=3 categories. In this example, the first weight w**1** may be associated with the first category **112** of FIG. **1**, the second weight w**2** may be associated with the second category **114** of FIG. **1**, and the third weight w**3** may be associated with the third category **115** of FIG. **1**. The content selector engine **178** may select how much of the first category **112** of the candidate content **108** to include in the honeypot content **134** based on the first weight w**1**. Additionally or alternatively, the content selector engine **178** may select how much of the second category **114** of the candidate content **108** to include in the honeypot content **134** based on the second weight w**2**. Additionally or alternatively, the content selector engine **178** may select how much of the Nth category **116** of the candidate content **108** to include in the honeypot content **134** based on the third weight w**3**.

The neural network **174** of FIG. **2** includes a trainer **202** configured to train the neural network **174** of FIG. **2** using labeled training data **204**. The labeled training data **204** is based on the activity log data **124**. The trainer **202** is configured to perform supervised learning using a back-propagation algorithm based on the labeled training data **204**. The back-propagation may include a backward pass through the neural network **174** that follows a forward pass through the neural network **174**. For example, in the forward pass, the outputs **176** corresponding to given inputs (e.g., the features **172**) are evaluated. In the backward pass, partial derivatives of the cost function with respect to the different parameters are propagated back through the neural network **174**. The network weights can then be adapted using any gradient-based optimization algorithm. The whole process may be iterated until the network weights have converged.

Although FIG. **2** illustrates an example of the neural network **174** of FIG. **1** as a multiplayer perceptron, in other examples, the neural network **174** of FIG. **1** is implemented as a Restricted Boltzmann machine or a Deep Belief Network that is trained using training data based on the activity log data **124** and that is configured to generate output responsive to the features **172**.

With reference to FIG. **3**, a computer-implemented method **300** of dynamically configuring a honeypot is described. The computer-implemented method **300** may be performed by the web crawler **104**, the honeypot logger **122**, and the honeypot configuration engine **142** described above with reference to FIG. **1**.

The computer-implemented method **300** includes, at **302**, crawling, by a web crawler, one or more webpages to gather information, resulting in gathered information. The web crawler may correspond to the web crawler **104** described above with reference to FIG. **1**, and the one or more webpages may correspond to the one or more webpages **133** described above with reference to FIG. **1**. The gathered information may correspond to the gathered information **118** described above with reference to FIG. **1**. For example, the gathered information may include current news articles and social media activity about regarding a company that uses the system **100**. For example, the web crawler **104** of FIG. **1** may be configured to be connected to the Internet **101** via a wired or wireless connection, such as a WLAN, and the web crawler **104** may configured with a web crawling capability, such as Blekko™ or AlchemyData News, to crawl the web to gather information (e.g., articles, documents, blog material, social media information regarding the company) from websites.

The computer-implemented method **300** includes, at **304**, obtaining, by a honeypot logger, activity log data of one or more hackers that access a portion of honeypot content deployed by a honeypot. The honeypot logger may correspond to the honeypot logger **122** described above with reference to FIG. **1**. The honeypot may correspond to the honeypot **102** described above with reference to FIG. **1**, the honeypot content may correspond to the honeypot content **134** described above with reference to FIG. **1**, and the portion of the honeypot may correspond to the portion **135** described above with reference to FIG. **1**. The activity log data may correspond to the activity log data **124** of FIG. **1** and may be obtained as described above with reference to FIG. **1**. For example, the activity log data may be obtained by the honeypot logger **122** of FIG. **1** using a keystroke logging technique. However, the activity log data may be obtained using one or more techniques additional or alternative to keystroke logging.

The computer-implemented method **300** further includes, at **306**, dynamically configuring, by a machine capable of learning, the honeypot using the activity log data and the gathered information. The honeypot may be dynamically configured using the honeypot configuration engine **142** described above with reference to FIG. **1**.

In some examples, dynamically configuring the honeypot using the activity log data and the gathered information includes parsing the activity log data to determine first categories associated with the portion of the honeypot content that is accessed by the one or more hackers. For example, the activity log data may be parsed using the category identifier **166** as described above with reference to FIG. **1**, and the first categories may correspond to the first categories **168** described above with reference to FIG. **1**. In some examples, the first categories are indicative of which categories of the honeypot content the one or more hackers are interested in. In examples in which dynamically configuring the honeypot includes parsing the activity log data, dynamically configuring the honeypot further includes performing topic detection on the gathered information to identify one or more topics. For example, the topic detection engine **162** described above with reference to FIG. **1** may perform topic detection on the gathered information **118** to determine the one or more topics **164** of FIG. **1** as described above with reference to FIG. **1**. In some examples, the one or more topics are indicative of current events that are likely to be of interest to the hackers. In these examples, dynamically configuring the honeypot further includes selecting the honeypot content based on the first categories and the one or more topics. Selecting the honeypot content based on information indicative of which categories of honeypot content the hackers are interested in and based on gathered information indicative of current events that are likely to be of interest to the hackers increases the chances that the honeypot will appear more attractive to the hackers.

In some examples of the computer-implemented method **300**, dynamically configuring the honeypot using the activity log data and the gathered information comprises determining a feature vector using the first categories and the one or more topics. For example, the feature generator **170** described above with reference to FIG. **1** may generate the feature vector **161** of FIG. **1** that includes the features **172** as described above with reference to FIG. **1**. In some of these examples, the computer-implemented method **300** further includes determining, by the machine capable of learning, weights associated with different categories of candidate content based on the feature vector. For example, the weights may correspond to the weights of the output **176** described above with reference to FIGS. **1** and **2**. In some examples, the weights correspond to the weights w**1**, w**2**, and w**3** described above with reference to FIG. **2**. The weights may be generated by the neural network **174** as described above with reference to FIGS. **1** and **2**. In some examples, the computer-implemented method **300** includes selecting the honeypot content from the candidate content based on the weights in the output from the neural network. For example, the content selector engine **178** may receive the output **176** including the weights, and may select how much of the candidate content **108** to include in the honeypot content **134** based on the weights in the output **176** as described above with reference to FIGS. **1** and **2**.

In some examples, dynamically configuring the honeypot using the activity log data and the gathered information includes using the activity log data and the gathered information to configure an amount of each category of candidate content to include in the honeypot content. For example, the honeypot configuration engine **142** of FIG. **1** may determine the one or more topics **164** and the first categories **168** based on the gathered information **118** and the activity log data **124**, respectively, and may determine the output **176** based on the features **172** generated by the feature generator **170** as described in FIG. **1**. The output **176** may include weights associated with the different categories **110** of FIG. **1**. In some examples, the different categories of content include a first category of content corresponding to financial data content, a second category of content corresponding to strategy content, a third category of content corresponding to health care data content, and a fourth category of content corresponding to intellectual property data content. In these examples, dynamically configuring the honeypot using the activity log data and the gathered information includes using the activity log data and the gathered information to configure an amount of the first category of content to include in the honeypot content, an amount of the second category of content to include in the honeypot content, an amount of the third category of content to include in the honeypot content, and an amount of the fourth category of content to include in the honeypot content.

In some examples, the computer-implemented method **300** further includes generating one or more documents or log files using the gathered information. For example, the content generator **182** of FIG. **1** may generate one or more documents of log files **192** as described above with reference to FIG. **1**, and the honeypot configuration engine **142** of FIG. **1** may add the one or more documents or log files to the candidate content **108** of FIG. **1**. Generating content based on the gathered information results in the candidate content **108** being more up to date. Because the honeypot content **134** is selected form the candidate content **108**, and because generating content based on the gathered information results in the candidate content **108** being more up to date, generating content based on the gathered information results in the honeypot content **134** being more up to date and therefore less likely to result in a hacker detecting that the honeypot is a honeypot.

FIG. **4** is a block diagram of an example of a system **400** in which aspects of the illustrative embodiments may be implemented. The system **400** is an example of a computer that can be applied to implement aspects of the system **100** (e.g., the web crawler **104**, the honeypot logger **122**, and the honeypot configuration engine **142**) of FIG. **1** and in which computer usable code or instructions implementing the processes for illustrative embodiments of the system may be located. In one illustrative embodiment, FIG. **4** represents a computing device that implements the system **100** of FIG. **1** augmented to include the additional mechanisms of the illustrative embodiments described hereafter.

In the depicted example, the system **400** employs a hub architecture including north bridge and memory controller hub (NB/MCH) **406** and south bridge and input/output (I/O) controller hub (SB/ICH) **410**. Processor(s) **402**, main memory **404**, and graphics processor **408** are connected to NB/MCH **406**. Graphics processor **408** may be connected to NB/MCH **406** through an accelerated graphics port (AGP).

In the depicted example, local area network (LAN) adapter **416** connects to SB/ICH **410**. Audio adapter **430**, keyboard and mouse adapter **422**, modem **424**, ROM **426**, a hard disk drive (HDD) **412**, compact disc read only memory (CD-ROM) drive **414**, universal serial bus (USB) ports and other communication ports **418**, and peripheral component interconnect/peripheral component interconnect express (PCI/PCIe) devices **420** connect to SB/ICH **410** through bus **432** and bus **434**. PCI/PCIe devices may include, for example, Ethernet adapters, add-in cards, and personal computer (PC) cards for notebook computers. PCI uses a card bus controller, while PCIe does not. ROM **426** may be, for example, a flash basic input/output system (BIOS).

HDD **412** and CD-ROM drive **414** connect to SB/ICH **410** through bus **434**. HDD **412** and CD-ROM drive **414** may use, for example, an integrated drive electronics (IDE) or serial advanced technology attachment (SATA) interface. Super I/O (SIO) device **428** may be connected to SB/ICH **410**.

An operating system runs on processor(s) **402**. The operating system coordinates and provides control of various components within the system **400** in FIG. **4**. In some embodiments, the operating system may be a commercially available operating system such as Microsoft® Windows 10®. An object-oriented programming system, such as the Java™ programming system, may run in conjunction with the operating system and provides calls to the operating system from Java™ programs or applications executing on the system **400**.

In some embodiments, the system **400** may be, for example, an IBM® eServer™ System P® computer system, running the Advanced Interactive Executive (AIX®) operating system or the LINUX® operating system. The system **400** may be a symmetric multiprocessor (SMP) system including a plurality of processors **402**. Alternatively, a single processor system may be employed.

Instructions for the operating system, the object-oriented programming system, and applications or programs are located on storage devices, such as HDD **412**, and may be loaded into main memory **404** for execution by processor(s) **402**. The processes for illustrative embodiments of the present disclosure may be performed by processor(s) **402** using computer usable program code, which may be located in a memory such as, for example, main memory **404**, ROM **426**, or in one or more peripheral devices **412** and **414**, for example.

A bus system, such as bus **432** or bus **434** as shown in FIG. **4**, may include one or more buses. The bus system may be implemented using any type of communication fabric or architecture that provides for a transfer of data between different components or devices attached to the fabric or architecture. A communication unit, such as modem **424** or LAN adapter **416** of FIG. **4**, may include one or more devices used to transmit and receive data. A memory may be, for example, main memory **404**, ROM **426**, or a cache such as found in NB/MCH **406** in FIG. **4**.

The present disclosure may be a system, a method, and/or a computer program product at any possible technical detail level of integration. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present disclosure.

The computer readable storage medium can be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a RAM, a ROM, an EPROM or Flash memory, an SRAM, a portable CD-ROM, a DVD, a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or eternal storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

Computer readable program instructions for carrying out operations of the present disclosure may be assembler instructions, instruction-set architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, configuration data for integrated circuitry, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++, or the like, and procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a LAN or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present disclosure.

Aspects of the present disclosure are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present disclosure. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the blocks may occur out of the order noted in the Figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

Turning now to FIGS. **5** and **6**, it is to be understood that although this disclosure includes a detailed description related to cloud computing, implementation of the teachings recited herein are not limited to a cloud computing environment. Rather, embodiments of the present disclosure are capable of being implemented in conjunction with any other type of computing environment now known or later developed.

Cloud computing is a model of service delivery for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, network bandwidth, servers, processing, memory, storage, applications, virtual machines, and services) that can be rapidly provisioned and released with minimal management effort or interaction with a provider of the service. This cloud model may include at least five characteristics, at least three service models, and at least four deployment models.

The cloud model characteristics may include on-demand self-service, broad network access, resource pooling, rapid elasticity, and/or measured service. On-demand self-service is a characteristic in which a cloud consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with the service's provider. Broad network access is a characteristic in which capabilities are available over a network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and personal digital assistants (PDAs)). Resource pooling is a characteristic in which the provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to demand. There is a sense of location independence in that the consumer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter). Rapid elasticity is a characteristic in which capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time. Measured service is a characteristic in which cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

The cloud model Service Models may include Software as a Service (SaaS), Platform as a Service (PaaS), and/or Infrastructure as a Service (IaaS).

SaaS is a service model in which the capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings. PaaS is a service model in which the capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including networks, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations. IaaS is a service model in which the capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls).

The cloud model Deployment Models may include private cloud, community cloud, public cloud, and/or hybrid cloud. Private cloud is a deployment model in which the cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on-premises or off-premises. Community cloud is a deployment model in which the cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on-premises or off-premises. Public cloud is a deployment model in which the cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services. Hybrid cloud is a deployment model in which the cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).

A cloud computing environment is service oriented with a focus on statelessness, low coupling, modularity, and semantic interoperability. At the heart of cloud computing is an infrastructure that includes a network of interconnected nodes.

Referring now to FIG. **5**, illustrative cloud computing environment **50** is depicted. As shown, cloud computing environment **50** includes one or more cloud computing nodes **10** with which local computing devices used by cloud consumers, such as, for example, PDA or cellular telephone **54**A, desktop computer **54**B, laptop computer **54**C, and/or automobile computer system **54**N may communicate. Cloud computing nodes **10** may communicate with one another. They may be grouped (not shown) physically or virtually, in one or more networks, such as Private, Community, Public, or Hybrid clouds as described hereinabove, or a combination thereof. This allows cloud computing environment **50** to offer infrastructure, platforms and/or software as services for which a cloud consumer does not need to maintain resources on a local computing device. It is understood that the types of computing devices **54**A-N shown in FIG. **5** are intended to be illustrative only and that cloud computing nodes **10** and cloud computing environment **50** can communicate with any type of computerized device over any type of network and/or network addressable connection (e.g., using a web browser).

Referring now to FIG. **6**, a set of functional abstraction layers provided by cloud computing environment **50** (FIG. **5**) is shown. It should be understood in advance that the components, layers, and functions shown in FIG. **5** are intended to be illustrative only and embodiments of the invention are not limited thereto. As depicted, the following layers and corresponding functions are provided:

Hardware and software layer **60** includes hardware and software components. Examples of hardware components include: mainframes **61**; RISC (Reduced Instruction Set Computer) architecture based servers **62**; servers **63**; blade servers **64**; storage devices **65**; and networks and networking components **66**. In some embodiments, software components include network application server software **67** and database software **68**. The hardware and software components of hardware and software layer **60** may serve as the underlying computing components on which cloud computing functions are executed in response to receipt of a request for performance of a function and/or service offered as a part of cloud computing environment **50** such as, for example, the domain adaptation described above.

Virtualization layer **70** provides an abstraction layer from which the following examples of virtual entities may be provided: virtual servers **71**; virtual storage **72**; virtual networks **73**, including virtual private networks; virtual applications and operating systems **74**; and virtual clients **75**. These virtual entities may enable a subscriber to cloud computing environment **50** to interact indirectly with the hardware and software components of hardware and software layer **60** indirectly via virtual layer **70** without having a specific knowledge of, or interacting directly with, hardware and software layer **60**. For example, a plurality of subscribers may interact with virtualization layer **70** to respectively access a corresponding plurality of virtual servers **71** and virtual storage **72** that all exist as separate threads, instances, partitions, etc., on a single server **62** and storage device **65**, respectively. In such a scenario, virtualization layer **70** may cause each virtual server **71** and virtual storage **72** to appear to each subscriber as a dedicated and seamless computing and storage device, while enabling efficient operation of the hardware and software components of hardware and software layer **60** by reducing a potential for redundancy of components.

In one example, management layer **80** may provide the functions described below via an abstraction layer such that a subscriber to cloud computing environment **50** may interact with virtualization layer **70** and/or hardware and software layer **60** indirectly via management layer **80** without having a specific knowledge of, or interacting directly with, virtualization layer **70** and/or hardware and software layer **60**. Resource provisioning **81** provides dynamic procurement of computing resources and other resources that are utilized to perform tasks within the cloud computing environment. Metering and Pricing **82** provide cost tracking as resources are utilized within the cloud computing environment, and billing or invoicing for consumption of these resources. In one example, these resources may include application software licenses. Security provides identity verification for cloud consumers and tasks, as well as protection for data and other resources. User portal **83** provides access to the cloud computing environment for consumers and system administrators. Service level management **84** provides cloud computing resource allocation and management such that required service levels are met. Service Level Agreement (SLA) planning and fulfillment **85** provides pre-arrangement for, and procurement of, cloud computing resources for which a future requirement is anticipated in accordance with an SLA. Management layer **80** enables a subscriber to cloud computing environment **50** to interact with cloud computing environment **50** through management layer **80** to perform tasks and functions (e.g., administrative tasks) separate from actual execution of functions in the cloud computing environment **50**. For example, an administrator may request access to a certain amount of computing resources (e.g., as provided in virtualization layer **70** and/or hardware and software layer **60**) in cloud computing environment **50** via management layer **80** without having a specific knowledge of, or interacting directly with, virtualization layer **70** and/or hardware and software layer **60**.

Workloads layer **90** provides examples of functionality for which the cloud computing environment may be utilized. The workloads and functions illustrated in workloads layer **90** are merely exemplary workloads and functions that may be executed in cloud computing environment **50** at the request or direction of a subscriber to cloud computing environment **50**, and are not limited to those explicitly recited herein. Examples of workloads and functions which may be provided from this layer include: mapping and navigation **91**; software development and lifecycle management **92**; virtual classroom education delivery **93**; data analytics processing **94**; transaction processing **95**; and honeypot configuration **96** (e.g., as described above with reference to the honeypot configuration engine **142** of FIG. **1** and the neural network **174** of FIG. **2**). These workloads and functions of workloads layer **90** may be end-user applications that enable a subscriber to cloud computing environment **50** to interact with any of management layer **80**, virtualization layer **70**, and/or hardware and software layer **60** indirectly via workloads layer **90** without having a specific knowledge of, or interacting directly with, any of management layer **80**, virtualization layer **70**, and/or hardware and software layer **60**. In this manner, the subscriber and/or an end user who accesses cloud computing environment **50** may not require any form of specialized knowledge relating to the composition or operation of any of management layer **80**, virtualization layer **70**, and/or hardware and software layer **60** to perform the workloads and functions of workloads layer **90**. In such a scenario, the workloads and functions of workloads layer **90** are said to be abstracted from management layer **80**, virtualization layer **70**, and hardware and software layer **60** because workloads layer **90** hides the underlying operation of management layer **80**, virtualization layer **70**, and hardware and software layer **60** from the subscriber and/or end-user while still enabling the subscriber and/or end-user to indirectly interact with management layer **80**, virtualization layer **70**, and/or hardware and software layer **60** to receive the computer processing benefits thereof via workloads layer **90**.

The descriptions of the various embodiments of the present disclosure have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the embodiments disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the described embodiments. The terminology used herein was chosen to best explain the principles of the embodiments, the practical application or technical improvement over technologies found in the marketplace, or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

What is claimed is:

1. A computer-implemented method, comprising:

crawling, by a web crawler, one or more webpages to gather information, resulting in gathered information;

generating candidate content based on the gathered information by generating fake notes appearing to be about the gathered information and appearing to tie the gathered information to fake project names assigned to honeypot content deployed by a honeypot;

obtaining, by a honeypot logger, activity log data of one or more hackers that access a portion of the honeypot content;

training a neural network using training data based on the activity log data;

determining a feature vector based on the gathered information and the activity log data;

determining, by the neural network, weights associated with different categories of the candidate content based on the feature vector; and

selecting the honeypot content from the candidate content based on the weights, wherein selecting the honeypot content based on the weights comprises selecting different amounts of the different categories of the candidate content based on the weights.

2. The computer-implemented method of claim **1**, wherein determining the feature vector comprises:

parsing the activity log data to determine first categories associated with the portion of the honeypot content;

performing topic detection on the gathered information to identify one or more topics; and

determining the feature vector based on the first categories and the one or more topics.

3. The computer-implemented method of claim **2**, wherein the first categories are indicative of which categories of the honeypot content the one or more hackers are interested in, and wherein the one or more topics are indicative of current events that are likely to be of interest to the one or more hackers.

4. The computer-implemented method of claim **1**, wherein the gathered information comprises current news articles and social media activity regarding a company that uses the honeypot.

5. The computer-implemented method of claim **2**, further comprising storing a set of template notes that include blank portions for insertion of the one or more topics.

6. The computer-implemented method of claim **1**, wherein the neural network includes an output layer, and wherein a number of nodes in the output layer corresponds to a number of the different categories.

7. The computer-implemented method of claim **1**, wherein the different categories of the candidate content include a first category of content corresponding to financial data content, a second category of content corresponding to strategy content, a third category of content corresponding to health care data content, and a fourth category of content corresponding to intellectual property data content, and wherein selecting the honeypot content includes determining, based on the weights, an amount of the first category of content to include in the honeypot content, an amount of the second category of content to include in the honeypot content, an amount of the third category of content to include in the honeypot content, and an amount of the fourth category of content to include in the honeypot content.

8. The computer-implemented method of claim **7**, further comprising:

generating one or more documents or log files using the gathered information; and

adding the one or more documents or log files to the candidate content.

9. A system, comprising:

a web crawler configured to crawl one or more webpages to gather information, resulting in gathered information;

a honeypot logger configured to obtain activity log data of one or more hackers that access a portion of honeypot content deployed by a honeypot; and

a honeypot configuration engine coupled to the web crawler and the honeypot logger and configured to:

generate candidate content based on the gathered information by generating fake notes appearing to be about the gathered information and appearing to tie the gathered information to fake project names assigned to the honeypot content;

train a neural network using training data based on the activity log data;

determine a feature vector based on the gathered information and the activity log data;

determine, by the neural network, weights associated with different categories of the candidate content based on the feature vector; and

select the honeypot content from the candidate content based on the weights, wherein selecting the honeypot content based on the weights comprises selecting different amounts of the different categories of the candidate content based on the weights.

10. The system of claim **9**, wherein, to select the honeypot content, the honeypot configuration engine is configured to:

parse the activity log data to determine first categories associated with the portion of the honeypot content;

perform topic detection on the gathered information to identify one or more topics; and determine the feature vector based on the first categories and the one or more topics.

11. The system of claim **10**, wherein the first categories are indicative of which categories of the honeypot content the one or more hackers are interested in, and wherein the one or more topics are indicative of current events that are likely to be of interest to the one or more hackers.

12. The system of claim **9**, wherein the different categories of the candidate content include a first category of content corresponding to financial data content, a second category of content corresponding to strategy content, a third category of content corresponding to health care data content, and a fourth category of content corresponding to intellectual property data content, and wherein to select the honeypot content, the honeypot configuration engine is configured to determine, based on the weights, an amount of the first category of content to include in the honeypot content, an amount of the second category of content to include in the honeypot content, an amount of the third category of content to include in the honeypot content, and an amount of the fourth category of content to include in the honeypot content.

13. The system of claim **12**, wherein the honeypot configuration engine is further configured to:

generate one or more documents or log files using the gathered information; and

add the one or more documents or log files to the candidate content.

14. A computer program product comprising a computer readable storage medium having program instructions embodied therewith, wherein the program instructions are executable by a computer to cause the computer to:

crawl one or more webpages to gather information, resulting in gathered information;

generate candidate content based on the gathered information by generating fake notes appearing to be about the gathered information and appearing to tie the gathered information to fake project names assigned to honeypot content deployed by a honeypot;

obtain activity log data of one or more hackers that access a portion of the honeypot content deployed by the honeypot;

train a neural network using training data based on the activity log data;

determine a feature vector based on the gathered information and the activity log data;

determine, by the neural network, weights associated with different categories of the candidate content based on the feature vector; and

select the honeypot content from the candidate content based on the weights, wherein selecting the honeypot content based on the weights comprises selecting different amounts of the different categories of the candidate content based on the weights.

15. The computer program product of claim **14**, wherein the program instructions that are executable by the computer to cause the computer to select the honeypot content are executable by the computer to cause the computer to:

parse the activity log data to determine first categories associated with the portion of the honeypot content;

perform topic detection on the gathered information to identify one or more topics; and

determine the feature vector based on the first categories and the one or more topics.

16. The computer program product of claim **15**, wherein the first categories are indicative of which categories of the honeypot content the one or more hackers are interested in, and wherein the one or more topics are indicative of current events that are likely to be of interest to the one or more hackers.

17. The computer program product of claim **14**, wherein the different categories of the candidate content include a first category of content corresponding to financial data content, a second category of content corresponding to strategy content, a third category of content corresponding to health care data content, and a fourth category of content corresponding to intellectual property data content, and wherein the program instructions that are executable by the computer to cause the computer to select the honeypot content by determining, based on the weights, an amount of the first category of content to include in the honeypot content, an amount of the second category of content to include in the honeypot content, an amount of the third category of content to include in the honeypot content, and an amount of the fourth category of content to include in the honeypot content.

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